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Laser Assisted Particle Removal

Chemical Mechanisms

- Photochemical reactive removal
- Photo- + thermo-chemical reactive removal

Mechanical Mechanisms

- Particle deformation
- Substrate deformation
- Energy transfer medium explosive evaporation

FIG. 1

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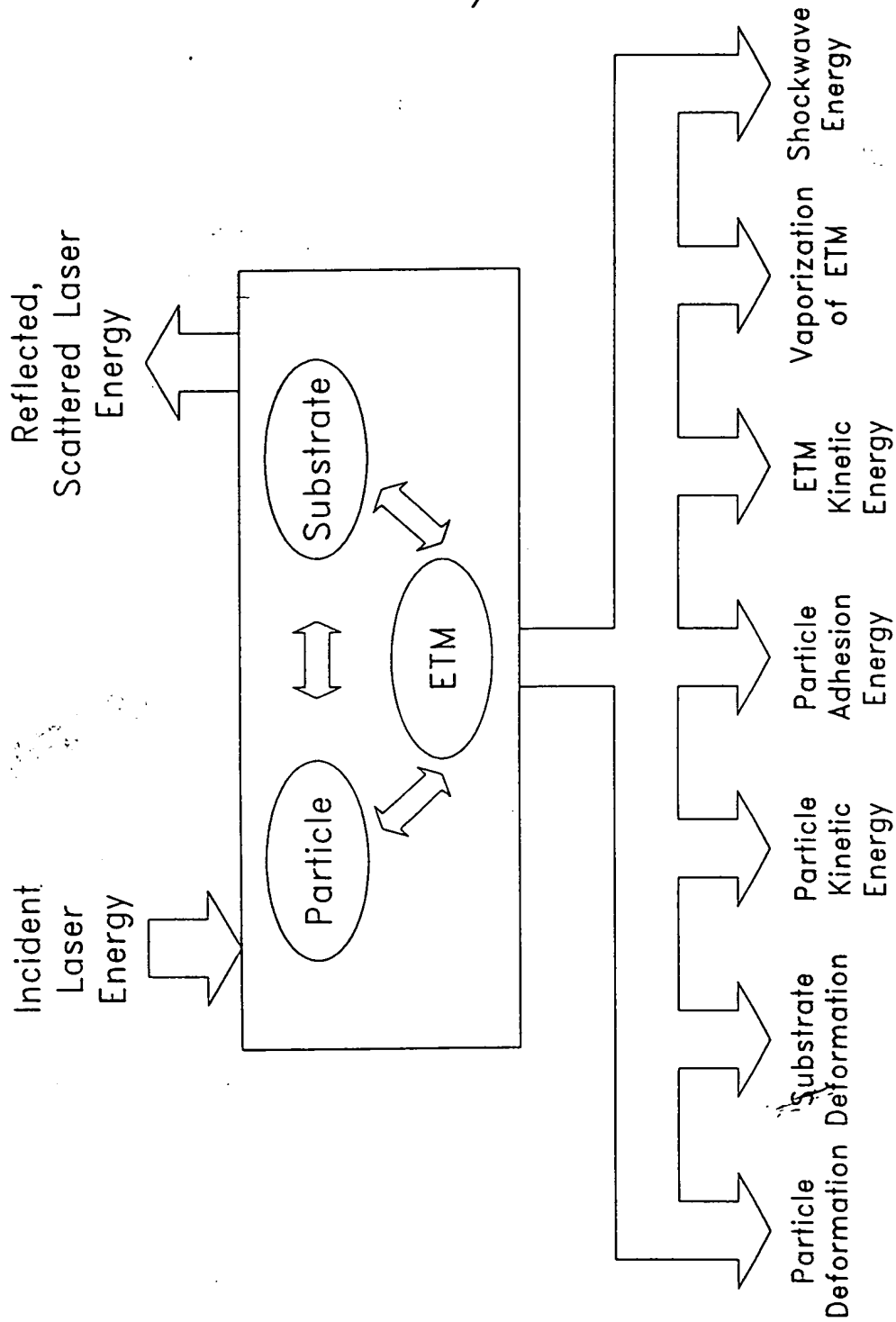


FIG. 2

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Absorption Medium	Particle	ETM	Substrate with ETM	Substrate without ETM
Removal Mechanism	Rapid thermal expansion of particle	Explosive evaporation of ETM	Microbubble formation at liquid/solid interface	Rapid thermal expansion of the substrate
wavelength	$\lambda < \text{Particle Diameter}$	$\lambda > \text{Particle Diameter}$	$\lambda > \text{Particle Diameter}$	$\lambda > \text{Particle Diameter}$ or $\lambda < \text{Particle Diameter}$ if α_{particle} is low
Energy Absorption	$\alpha_{\text{particle}} > \alpha_{\text{substrate}}$	High α_{ETM}	High $\alpha_{\text{substrate}}$	High $\alpha_{\text{substrate}}$
Substrate Damage	-Melting/Ablation of particle	Shockwave, substrate absorption	-Melting/Ablation of particle or substrate -Shockwave in ETM	Melting/Ablation of particle or substrate
Particle Removal Threshold	$\Phi_{\text{th}} = 0.01-0.08 \text{ J/cm}^2$ $I_{\text{th}} = 1-11 \text{ MW/cm}^2$ $D = 20 \mu\text{m}$	$\Phi_{\text{th}} = 0.65-2.2 \text{ J/cm}^2$ $I_{\text{th}} = 3-11 \text{ MW/cm}^2$	$\Phi_{\text{th}} = 0.02-0.3 \text{ J/cm}^2$ $I_{\text{th}} = 2-600 \text{ MW/cm}^2$ $t = 0.03-20 \text{ ns}$	$\Phi_{\text{th}} = 0.02-0.3 \text{ J/cm}^2$ $I_{\text{th}} = 1-30 \text{ MW/cm}^2$ $t = 7-30 \text{ ns}$

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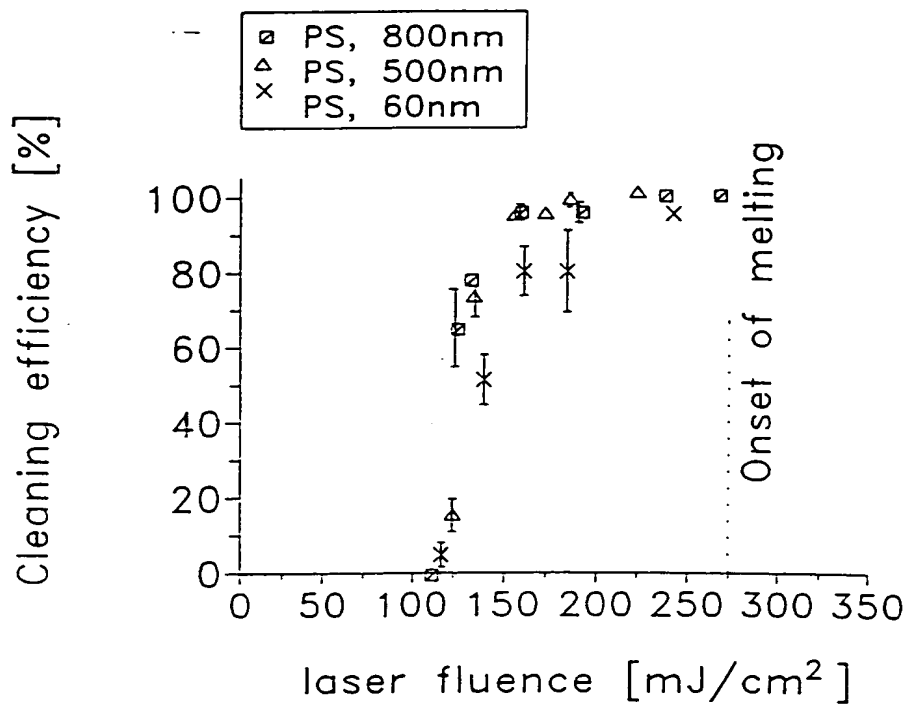


FIG. 4

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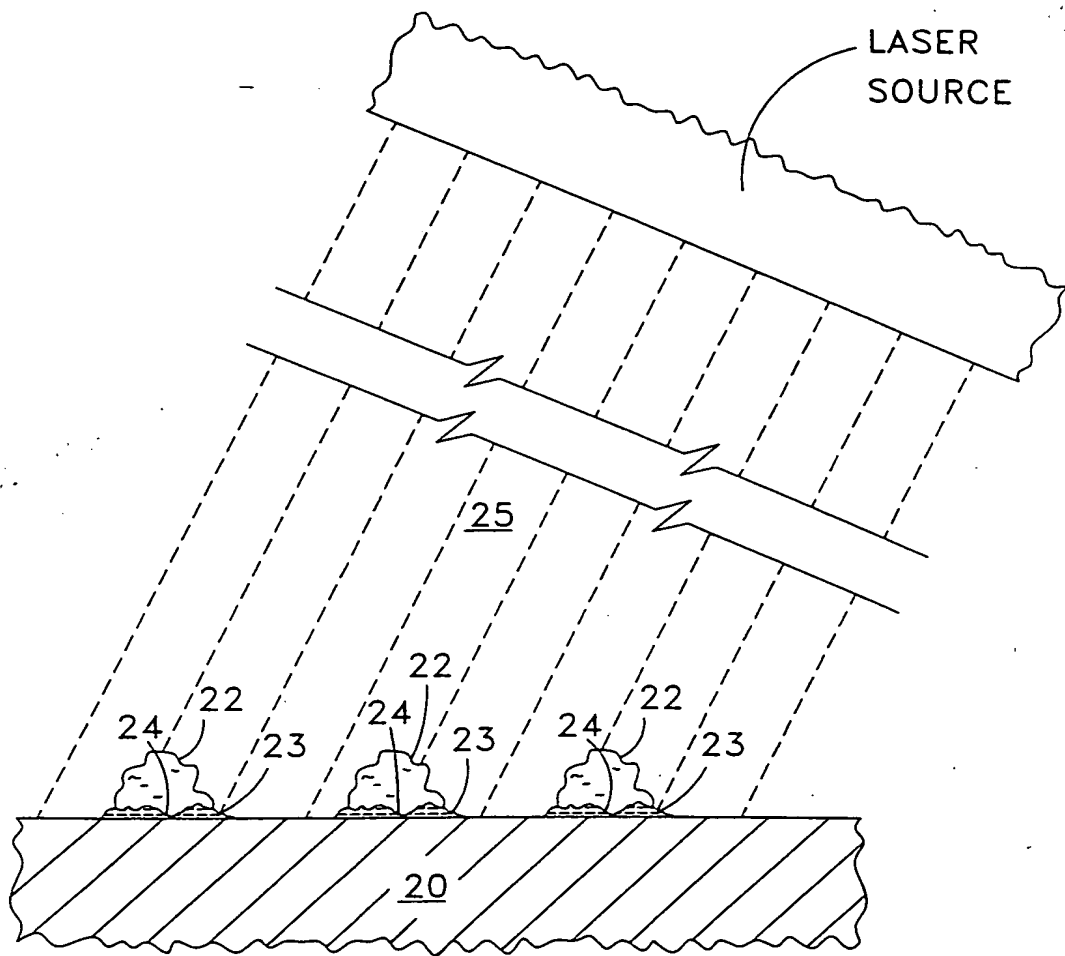


FIG. 5

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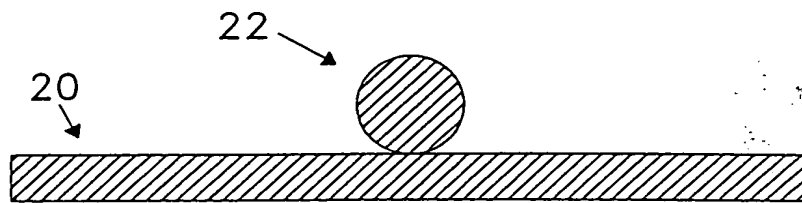


FIG. 6A

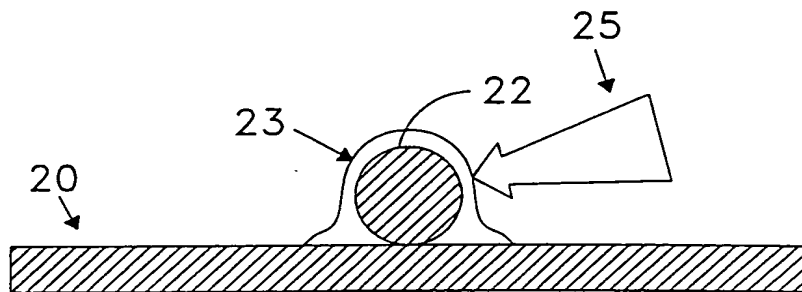


FIG. 6B

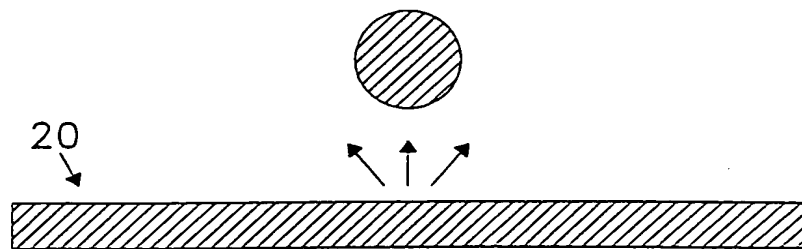


FIG. 6C

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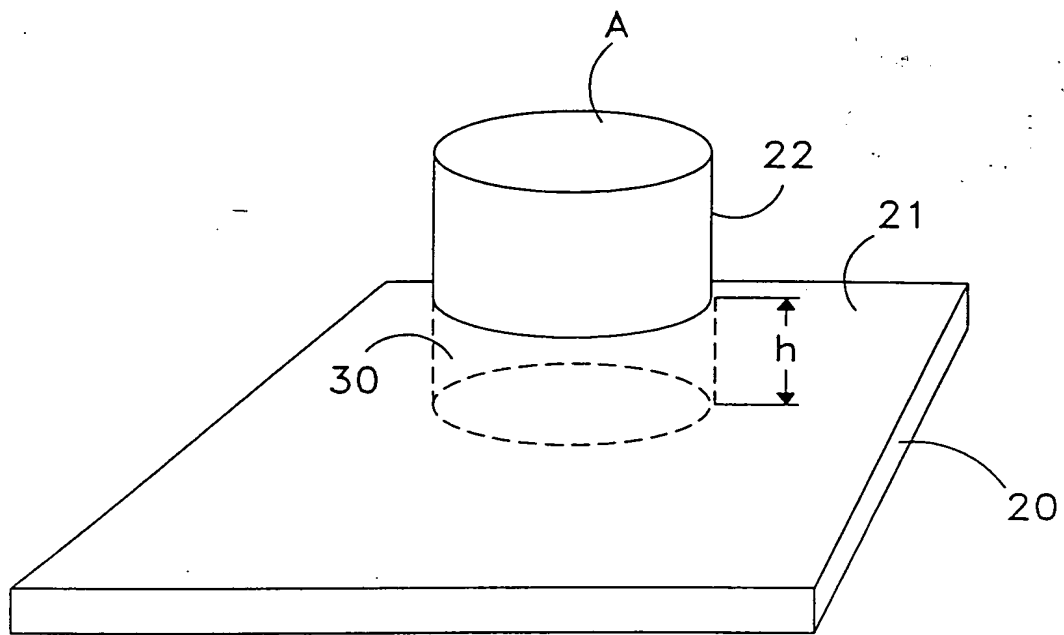


FIG. 7

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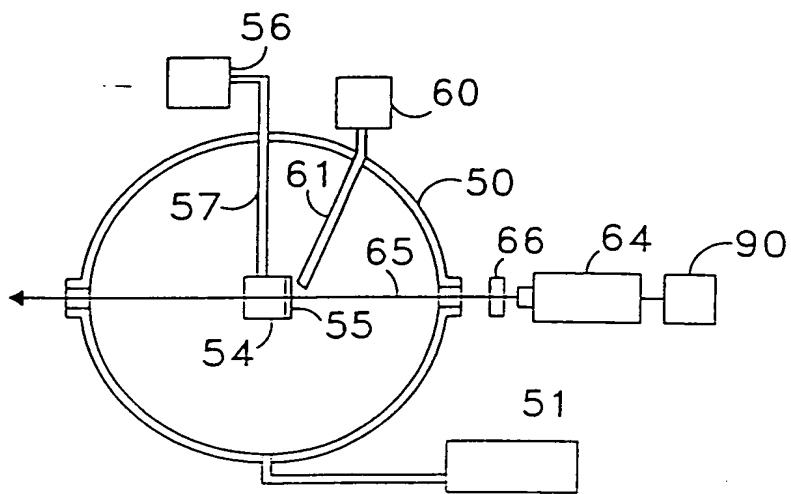


FIG. 8

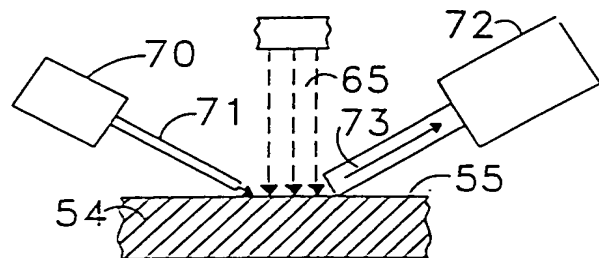


FIG. 9

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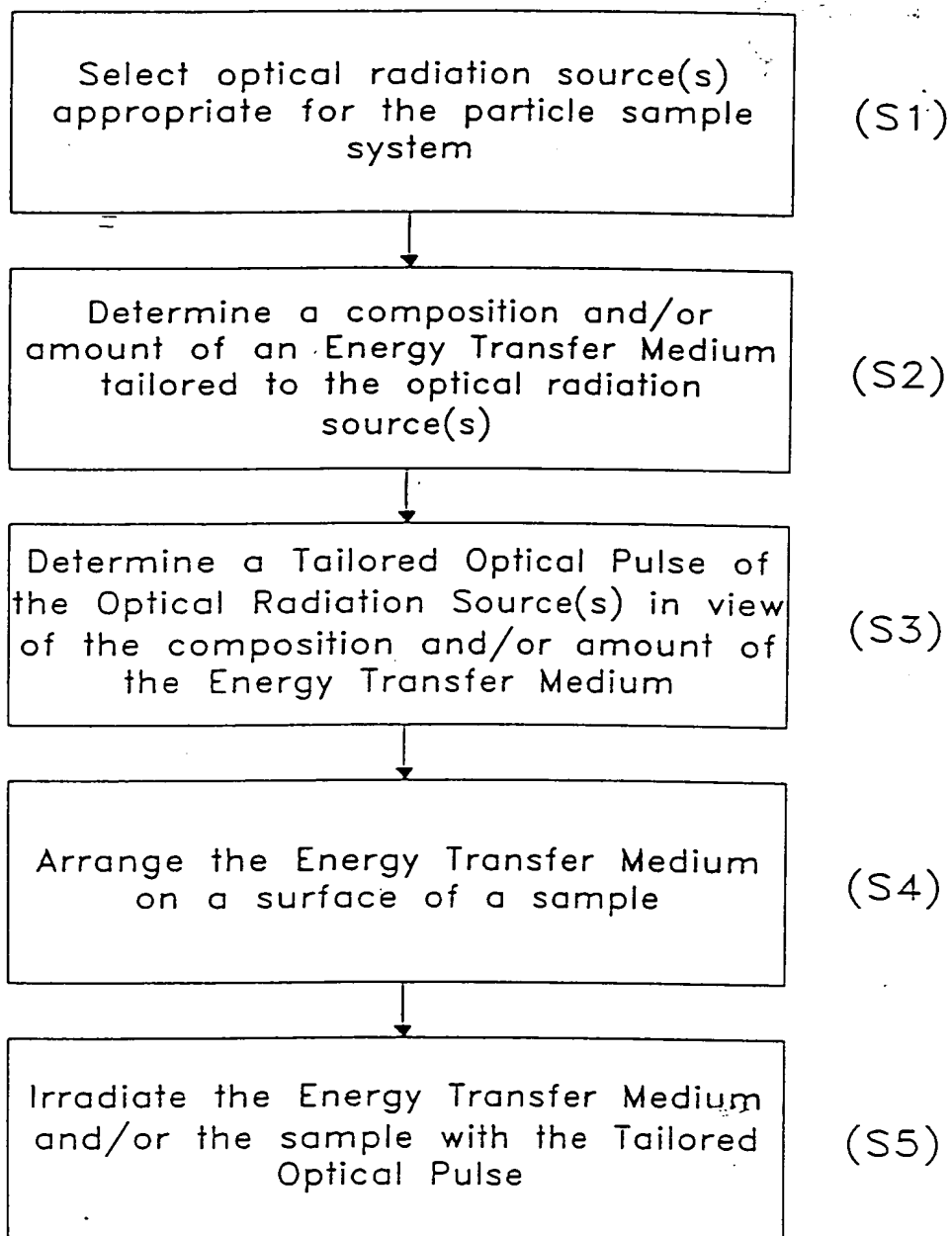


FIG. 10

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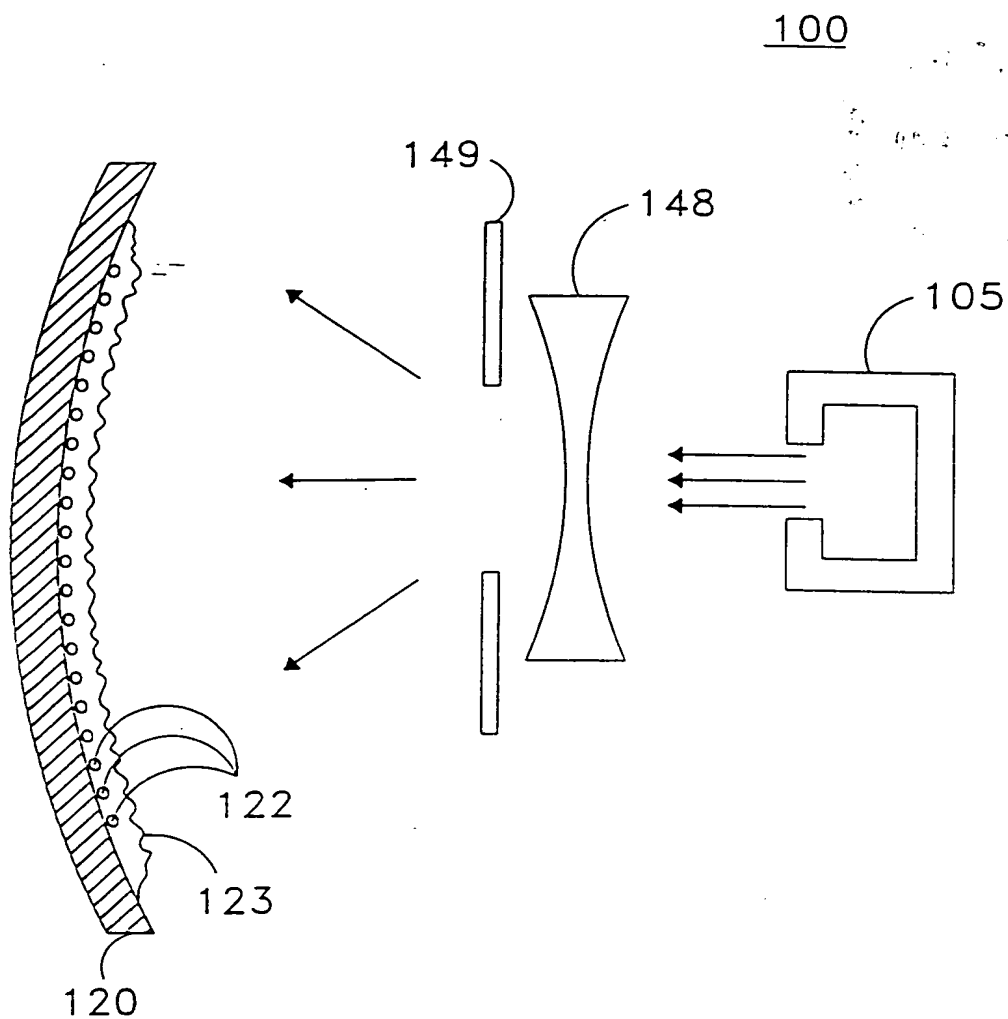
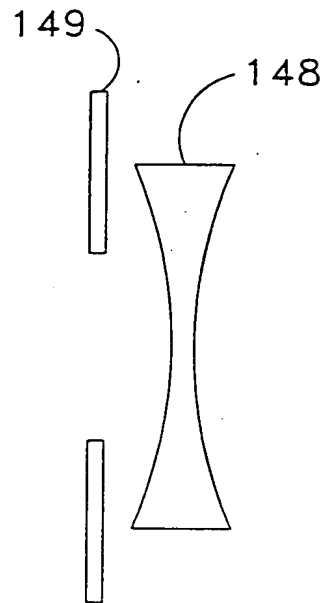
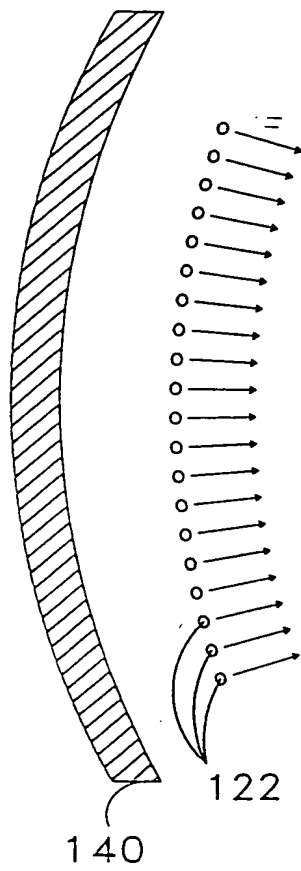


FIG. 11

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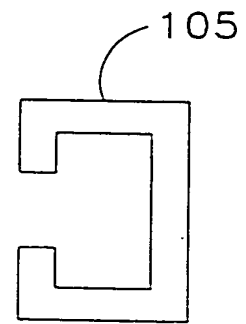


FIG. 12

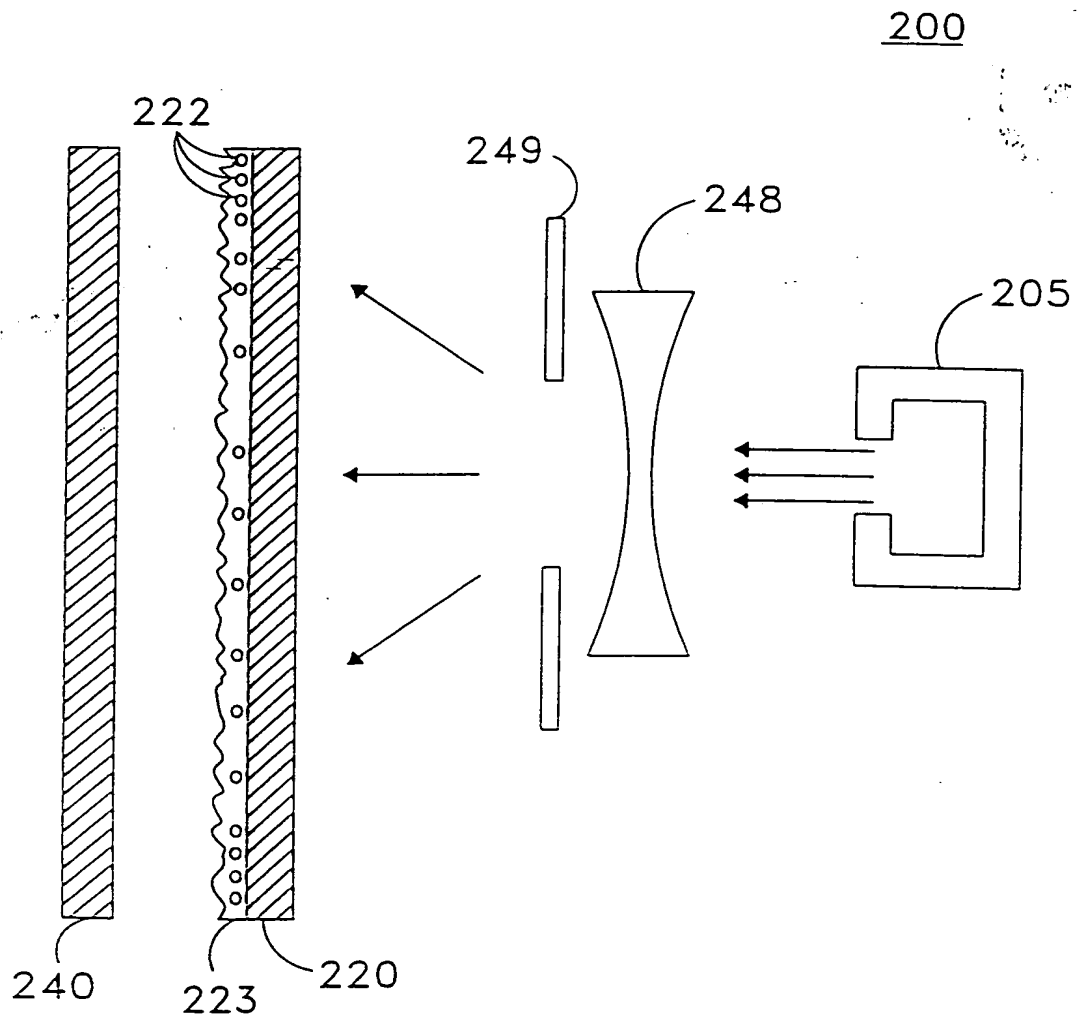


FIG. 13